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AMERICAN FERTILIZER

" That man is a benefactor to his race who makes two blades of grass to grow where but one grew before."

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Leaf Analysis As a Means of Determining The Fertilizer Requirement of Crops*

By WALTER THOMAS, WARREN B. MACK, and ROBERT H. COTTON

THE history of chemistry and plant physiology in their application to agriculture is very largely the story of the search for the simplest and most economical method of determining the fertilizer requirements of plants.

The first hypothesis was that plants took from the soil the things they needed. The system of determining the fertilizer requirements known as taking the "inventory of the soil," widely used up to a quarter of a century ago, was based on this hypothesis. Average crops were analyzed for nitrogen, phosphoric acid, and potash; the soil also was analyzed to ascertain what quantity of these elements per acre the soil contained in a suitable form for plant nutrition. The amount of an element necessary, if any, was then obtained by difference.

Although simple, this method now is abandoned because of two fallacies. First, the amount of an element in the plant is conditioned by the amount available in the soil and not by its needs; and there is no method of soil analysis that determines the amount of an element available with any degree of exactness. Furthermore, different species have different feeding powers. The second fallacy is that the mineral composition of a particular species is assumed to be a fixed entity. This is not the case: the composition varies over a wide range as the result of differences in soil, variety of crop, period of growth, climate, water supply, fertilizer, cultural practices, and other environmental conditions.

Accordingly, any method for determining the fertilizer requirements of crops must fulfill two conditions: (1) It must deal with the requirements of each species separately. (2) The method must take full cognizance of the comparative nature of the results. By this is meant that comparison must be made with a standard or ideal plant, under uniform conditions with respect to physiological age and climate, for both the standard plant and the plants whose requirements are being investigated.

The logical approach to the problem is to find out how fertilizers affect the nutrition of the plant. Diagnosis by means of analysis of the entire plant is, in general, not practical. Apart from the disadvantages of having to dig up whole plants, the results of the analysis of a mass of heterogeneous organs possessing different functions, each nourished in its own particular manner, is not a sufficiently sensitive index of differences in nutrient conditions.

The possibility of employing the data obtained by chemical analysis of leaf material as a means of revealing the nutrient requirements of crops had repeatedly attracted the attention of physiologists as early as 1870. But the methods used failed for a number of reasons to provide a satisfactory index of nutrient relationships. The composition of a leaf is now known to depend upon its physiological or metabolic age, so that if the leaf is to be made the basis for diagnosis one cannot, as did the early investigators, compare the gross analysis of leaves of all ages, but only leaves of the same age from all plants in the experiment must be taken for analysis.

*Authorized for publication on January 29, 1943, as Paper No. 1162 in the Journal Series of the Pennsylvania Agricultural Experiment Station, State College, Pa.

This condition fulfilled, a definite procedure must be worked out and its validity tested experimentally. For the method to be valid, it must be shown that the results from the analysis from the properly sampled leaves from plants differently fertilized must mirror the changes in the development (growth) of the differently fertilized plants. It is unnecessary to describe here the experiments made to establish the soundness of the method, as these have been published in scientific journals. From the experiments the fact was ascertained that each type of development (growth) of a particular species is associated with a definite mode of chemical evolution as determined by the composition of leaves taken at various stages during the growth cycle.

Tabulation of Experiments

To make the subject understandable to those engaged particularly in the fertilizer industry, we shall examine the relationship between the composition of leaves of corn plants, their fertilizer treatments, and their yields. In Table I are recorded the plot numbers and treatments of four differently fertilized plots in the Jordan field experiments of this Experiment Station, together with yields of grain. The four plots taken to illustrate the method receive the same quantities of phosphoric acid and potash as superphosphate and muriate respectively; but the nitrogen supply varies both as to quantity and source. Plot No. 28 received three times the unit amount of nitrogen, as sodium nitrate; plot No. 26 the unit amount of nitrogen, also as sodium nitrate; plot No. 9, the unit amount of nitrogen, as dried blood; and plot No. 7 received no nitrogen, only superphosphate and potash.

Columns 3, 4, and 5 give the percentages of nitrogen, phosphoric acid, and potash respectively in the third leaf from the base. The last column shows the yields of grain in pounds per plot.

The highest yielding of these plots is No. 28 receiving three times the unit amount of nitrogen as nitrate of soda. The yield of No. 26, which received one-third as much nitrogen (also as nitrate of soda) as that of No. 28, is slightly lower. When, however, as in No. 9, nitrate of soda is replaced by the same amount of nitrogen as in No. 26, but as dried blood, a marked reduction (26 per cent below No. 26) in yield occurs; the yield is still further reduced when nitrogen is omitted altogether. These, then, are the facts given by the yields.

Let us now examine the data on leaf analysis. Column 2 of Table I shows that as the quantity of nitrogen in the fertilizer is increased, the percentage of nitrogen in the leaves increases and moreover, as yields progressively increase, the percentage of nitrogen in the leaf also progressively increases. We find, therefore, a relationship between nitrogen in the fertilizer, (*i. e.*, the nitrogen supply) and the nitrogen content of the leaf and between nitrogen in the leaf and the yield. Futhermore, since the nitrogen content of leaves from plants on $N_{DB}PK$, Plot No. 9, is less than in those of $N_{Na}PK$, Plot 26, the nitrogen of dried blood is shown to be more slowly assimilated (available) than that of sodium nitrate. So far then as the percentage content of nitrogen in the dried foliage is concerned, there is agreement in these four plots between the composition of the leaf and the cultural facts. The relationship between the percentages of phosphoric acid and potash respectively in the leaf and the fertilizer on the one hand and yields on the other is less evident. Although the same amounts of these elements have been applied to all four plots, the qualities of these elements in the leaf are not equal from all four plots, and the differences are greater than the experimental error of analysis. It is not, therefore, apparent from these figures what role phosphoric acid and potash play in the nutrition of the plants from these four plots. Nevertheless, as we shall learn later, a relationship does exist.

TABLE I

Plot numbers, fertilizer treatment, percentages of nitrogen, phosphoric acid and potash in the dried leaves, the intensities of nutrition and the composition of NPK-units in the 3rd leaf from the base.

Treatment	Plot No.	N %	P_2O_5 %	K_2O %	$(N+P_2O_5+K_2O)$ per cent (intensity factor)	Composition of NPK-unit $N : P_2O_5 : K_2O$ (quality factor)	Grain yield lbs. per plot
$(3N)_{Na}PK$	28	3.037	0.521	3.173	6.731	70.51 : 7.32 : 22.17	723
$N_{Na}PK$	26	2.860	0.509	3.178	6.547	69.57 : 7.58 : 22.84	705
$N_{DB}PK$	9	2.662	0.520	3.328	6.510	67.75 : 7.73 : 24.51	520
PK	7	2.340	0.468	3.154	5.962	65.48 : 7.95 : 26.57	497

The subscripts N_{Na} and N_{DB} indicate that nitrogen was applied as sodium nitrate and dried blood respectively.

Thus far, we have considered the effect factor of the fertilizer elements *separately* in their influence on yields. We know, however, from field experience that each element influences the action of the others. And this influence or effect factor can, by methods of plant physiology, be expressed in precise terms. For adequate treatment, consequently, it is necessary to consider these three major fertilizer elements together as an entity. Returning to Table I, the fifth column shows for each plot the sum of the percentages of nitrogen, phosphoric acid and potash in the leaf at the moment of sampling. Inasmuch as each value denotes the *quantity* of the fertilizer elements in the leaf from a particular plot, it is a magnitude expressing the ***intensity of nutrition*** resulting from the particular fertilizer treatment considered. It will be observed that the intensities increase progressively with increase in yield. A relationship exists, therefore, between these values and the yields. The *quantity* factor, however, cannot be used solely as an index of the effectiveness of a fertilizer, although experiments have established that a relatively high ***intensity of nutrition*** with respect to the fertilizer elements is necessary for high yields (low intensities invariably resulting in low yields). If, however, an element is taken in by the plant in very large quantities, harmful results may follow; in such cases a high intensity will result. We need, therefore, an additional measure that will indicate the *quality* of nutrition; that is, an expression that will show the relationships of nitrogen, phosphoric acid and potash in the leaf to one another. This magnitude can be obtained by finding out the proportion which each element contributes to the total amount present in the leaf. Thus, in the case of the highest yielding plot, No. 28, we can write

$$\%\,N + \%P_2O_5 + \%K_2O = \underset{\text{Intensity}}{\%\,(N + P_2O_5 + K_2O)}$$

$$3.037 + 0.521 + 3.173 = 6.731$$

Dividing by 6.731, we get:

$$0.4512 + 0.0774 + 0.4714 = 1$$

The *quality* factor of nutrition, therefore, can be represented as the proportion which each contributes to a unit amount of all three. But since we are considering the chemical reactions in the leaf at the moment of sampling, it is not scientific to express the *quality* factor in terms of percentage values. Chemical reactions occur between values known as "chemical equivalent values." When the percentage values in our example are converted into milligram equivalent numbers, they become:

$$N : P_5O_2 : K_2O$$
$$0.7051 + 0.0732 + 0.2217 = 1$$

And to avoid fractions, these values are multiplied by 100. We then have

Composition of the NPK-unit

$$N : P_2O_5 : K_2O$$
$$70.51 : 7.32 : 22.17 = 100$$

These are the values shown for plot No. 28 in Column 6 of the table. This is designated the composition of the *NPK-unit* or more concisely, just *"the NPK-unit."* It represents the equilibrium (or balance) between the fertilizer elements in the leaf chosen at the moment of sampling. One notes that these *NPK-units* possess characteristics not inherent in the percentage quantities. The values for phosphoric acid and potash in the leaves from the respective plots are no longer irregular. Now, both decrease progressively as yields increase. Since nitrogen increases progressively with increase in yield, the increase in the nitrogen of the *NPK-unit* is made at the expense both of the phosphoric acid and potash. The use of the concepts of the *quantity* and *quality* factors in nutrition can now be formulated in the statement, established experimentally, that a fertilizer intervenes in the nutrition of a plant so as to affect a change in (1) the intensity of nutrition or (2) in the composition of the *NPK-unit* or in both (1) and (2) simultaneously. In interpreting results, therefore, both factors are to be considered.

A Descriptive Diagram

As a visual aid in determining the relationships between the *NPK-unit* values, it becomes much simpler to show them by means of a figure. The relationship between any three variables is easily presented on an equilateral triangle. The system is not difficult to understand; it is much used in industry to plot relationships, for example, between the three variables labor, materials, and overhead. Without going into the details of the properties of equilateral triangles, one may point out that if each side is taken to represent 100 in terms of the unit selected, the sum of the perpendiculars drawn from any point inside the triangle to the three sides will always be equal to 100, wherever this point is chosen in the triangle. Fig. 1 shows such a triangle. In order that we may use a

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Principal Articles in This Issue

Cotton Farmers to Plant Full Allotments After Meeting War Goals

Secretary of Agriculture Claude R. Wickard, on February 6th, called on southern farmers to plant as much of their 1943 farm cotton allotments as possible, after meeting special war crop goals. He asked, however, that cotton allotments not be exceeded.

Stressing the value of cotton and its products in the war effort, the Secretary said it is second in importance only to the designated war crops on southern farms. Cottonseed meal is one of the principal protein feeds in livestock production, while cottonseed oil is one of the best edible oils. Cotton linters are used in making ammunition.

"The first responsibility of every farmer," the Secretary said, "is to increase his production of meats, poultry and dairy products, oil crops, and certain fruits and vegetables for processing, in order to meet the ever-increasing demands of our armed forces and our allies.

"On southern farms, it is also important that farmers give attention to planting up to their full cotton allotments, where such action will not tend to decrease war crop production. This is especially true," he added, "in areas where expansion in war crops is not feasible and in areas adapted to production of longer staple cotton."

The Secretary pointed out the value of cottonseed in providing a good protein feed for livestock, as well as furnishing oil to meet war needs. Although the seed is only a by-product of cotton lint production, he said an acre of cotton, based on the United States' average for the past five years, will yield 205 pounds of meal and 70 pounds of oil. On a comparative basis, an acre of peanuts will yield approximately 310 pounds of meal and 215 pounds of oil, and an acre of soybeans will yield around 910 pounds of meal and 170 pounds of oil.

Making a comparison on the basis of the amount of labor required to produce these same crops, the Secretary said a man-hour of labor will result in a production as follows: cotton—2.1 pounds of meal and 0.7 pounds of oil; peanuts—5.2 pounds of meal and 3.5 pounds of oil; and soybeans—75.6 pounds of meal and 14.2 pounds of oil.

Deliveries of Potash Salts, 1942

The American Potash Institute, Inc., announces that deliveries of agricultural potash by the four major producing Companies within the continental United States, Canada, Cuba, Puerto Rico, and Hawaii during the fourth quarter of the calendar year 1942 amounted to 165,883 tons of actual K_2O, equivalent to 327,716 tons of potash salts. Constituting this total were 232,899 tons of muriate, 69,028 tons of manure salts, and 25,789 tons of sulphate. In addition, deliveries for chemical uses amounted to 27,091 tons of salts, equivalent to 16,694 tons of K_2O. These figures include salts of domestic origin only.

For the calendar year 1942, deliveries of agricultural K_2O amounted to 596,311 tons, equivalent to 1,149,720 tons of potash salts, consisting of 849,236 tons of muriate, 193,050 tons of manure salts, and 107,434 tons of sulphate. In addition, deliveries for chemical uses amounted to 103,408 tons of salts, equivalent to 63,844 tons of K_2O.

POTASH DELIVERIES
Short Tons K_2O

	Calendar Year 1942	Calendar Year 1941
United States		
Muriate: 60 per cent	415,935	307,897
50 per cent	40,780	44,016
Manure Salts: 30 and 25 per cent	40,068	28,627
Sulphate and Sul. Pot.-Mag.	42,140	29,948
Total Agricultural	538,923	410,488
Canada	34,409*	21,734
Cuba	3,546	2,642
Puerto Rico	7,241	14,468
Hawaii	12,192	10,984
Total Agricultural	596,311	460,316
Chemical Potash	63,844	51,962
Grand Total	660,155	512,278

*Includes 8,174 tons K_2O in the form of manure salts.

Williams Retires from A. A. C.

Julian Y. Williams, who has a host of friends throughout the fertilizer industry, has resigned as vice-president and general sales manager of The American Agricultural Chemical Company. Mr. Williams has served the company in various capacities since June 1, 1915. He is retiring to his farm, "Mansfield," near Petersburg, Va.

December Sulphate of Ammonia

Continuing at slightly over 2,000 tons per day, the production of by-product sulphate of ammonia during December, 1942, totaled 63,813 tons, compared with 62,908 tons in November, according to the figures of the U. S. Bureau of Mines. Sales during the the month increased about 1.5 per cent, to 69,740 tons while stocks on hand at the end of the month decreased to 43,688 tons, a drop of 12.5 per cent.

Preliminary figures for the calendar year 1942 showed an output of 766,821 tons, an increase of about 3 per cent over 1941 production.

Production and sales of ammonia liquor also continued at the standard level during December. Sales during 1942 totaled 33,947 tons NH_3 as compared with 31,389 tons in 1941. Stocks on hand at the end of the year were down to 757 tons.

Tabulated figures for both sulphate of ammonia and ammonia liquor are as follows:

	Sulphate of Ammonia Tons	Ammonia Liquor Tons NH_3
Production:		
December, 1942	63,813	2,871
November, 1942	62,908	2,901
December, 1941	65,603	2,784
Calendar year, 1942	766,821	33,947
Calendar year, 1941	745,198	31,389
Sales:		
December, 1942	69,740	3,000
November, 1942	68,284	3,017
December, 1941	67,208	2,930
Calendar year, 1942	751,771	35,296
Calendar year, 1941	756,569	30,171
Stocks on hand:		
December 31, 1942	43,688	1,017
November 30, 1942	49,924	1,034
December 31, 1941	31,091	757
November 30, 1941	32,601	707

SULPHATE OF AMMONIA
1942

	Production Tons	Sales Tons
January	65,548	74,955
February	58,598	61,707
March	65,216	67,783
April	63,766	70,153
May	66,874	61,488
June	63,888	57,788
July	64,288	21,330
August	64,077	68,444
September	62,942	66,297
October	64,903	63,802
November	62,908	68,284
December	63,813	69,740
Total, 1942	766,821	751,771
Total, 1941	745,198	756,569

PASTURE NOTES

Compiled by R. H. LUSH, Pasture Specialist, the National Fertilizer Association

ALABAMA

Grow More Meat. Experiments have shown that well-set pastures, liberally fertilized and properly managed, will give 275 to 350 pounds of meat per acre. "This, of course, is above average for good pastures but illustrates what can be done under favorable conditions," says J. C. Lowery, extension agronomist.

CALIFORNIA

Pasture Saves Labor and Supplies Protein. Forty-five pigs were carried on three acres of barley and one acre of alfalfa from the middle of June until October 1st at the University Farm. Then a mixture of double dwarf milo grown with black-eyed cowpeas finished them for market at the rate of 1½ pounds' gain per day. Milo and tankage produced only one pound gain per day, while milo alone produced gains of only three-quarters pound per day. Cowpeas were grown successfully by two methods, either in the row with the milo or in alternate rows. Pacific Rural Press, December 12, 1942.

Record Meat Gains. J. D. Patterson, Surprise Valley, Modoc County, pastured 500 calves on 300 acres of meadow containing alsike clover from April 15th to October 1st. He figured that they produced 519 pounds of gain per acre during that period. Pacific Rural Press, November 28, 1942.

FLORIDA

Lespedeza Needs Plant Food. A good growth of lespedeza may be anticipated with a soil treatment of one-half to one ton of lime and 300 to 600 pounds of 0–14–10 or similar fertilizer. In a lespedeza-oats rotation, the oats should be fertilized with 300 to 400 pounds of a 0–14–10 or similar fertilizer in the fall, followed by 100 pounds per acre of a nitrogen carrier in early spring. The calcium, phosphorus and potassium content of lespedeza was increased greatly by fertilization with those elements. This effect on the nutritive value of the forage may be fully as important as its effect on total growth, report J. D. Warner and R. E. Blaser. Fla. Agr. Exp. Sta. Bul. No. 375, 1942.

GEORGIA

Fertilizer Clover. "Under most conditions fertilizer should be applied liberally in order to establish a good stand of crimson clover. Depending upon the character of the soil and fertilizer applications on the preceding crop, as much as 500 pounds per acre of a 4–8–8 or similar fertilizer may be required." J. L. Stephens and E. A. Hollowell, Jour. Amer. Soc. Agron., Vol. 34, No. 11, 1942.

ILLINOIS

Lespedeza Valuable for Beef Production. The value of lespedeza pasture for beef production is shown at the Dixon Springs Experiment Station where nine head of steers on 10 acres of pasture made gains of 1.9 pounds a head daily over a five-month period.

KANSAS

Wasted Time. In a study of the grazing habits of milking cows, it was found that they spent an average of 5.6 hours of grazing on good pastures, 6.5 hours on fair pastures, and 7.3 hours on poor pastures. Thus 31 per cent more time was spent grazing on poor pasture than on good pasture. The cows lay down an average of 4 times daily on good pasture, and only 2 times daily on fair and poor pasture. Water was consumed from 3 to 4 times during the day with no apparent relationship to quality of pasture. In a study of dry cows and yearling heifers on Balbo rye, the animals spent an average of seven hours grazing, 4 hours standing or walking, and 13 hours lying down. On the basis of a 14-hour day and a 10-hour night, they grazed 40 per cent of the time in daytime and 16 per cent of the time at night. F. W. Atkeson, A. O. Shaw, and H. W. Cave, Jour. Dairy Sci., Vol. XXV, No. 9, 1942.

KENTUCKY

Fertilizer Trebles Lespedeza Yield. In a test on the farm of R. A. Ledford, Trigg County, lespedeza on untreated land grew 8 inches tall; where either limestone or phosphate was used, 10 inches; where both limestone and phosphate were applied, 15 inches; and where limestone, phosphate and potash were used, 25 inches.

LOUISIANA

Five Times as Much Beef Gains on Fertilized Pastures. Old cotton land of low fertility produced five times as much beef when seeded with carpet grass, Bermuda grass, Dallis grass, and common lespedeza, and

fertilized with 400 pounds of 3–12–8 fertilizer per acre, as unimproved forest reserve land near Dry Prong, Grant Parish.

MASSACHUSETTS

Added Fertility Paid. An average of 84 top-dressing treatments on grass sod gave 3,128 pounds of hay from manure alone, 4,945 pounds from manure plus 50 pounds nitrogen, or 1,817 pounds increase in hay production from the use of chemical nitrogen. Large increases were obtained in 45 per cent of the trials, chiefly where the manure applications were moderate or light. In several tests, complete fertilizer added to manure gave increased yields of more thrifty grass. From the results of these trials, it would appear profitable to apply some nitrogen and extra potash if feed is needed, and the rate of manure applied is light. Report by Ralph W. Donaldson, extention agronomist, M. S. C.

MISSISSIPPI

Watch Pasture Respond. Fertilization of pastures deficient in plant food may consist of 250 to 300 pounds of 20 per cent superphosphate or its equivalent. Potash can be applied profitably to pastures where other feed crops respond. Lime may be applied where needed at the rate of 1,000 to 3,000 pounds, and barnyard manure at the rate of four or five tons to the acre. Applications of fertilizer should be followed by light disking.

MISSOURI

Feeding Value Depends on Soil. Preliminary results presented by Dr. G. E. Smith, University of Missouri, at the recent meeting of the American Society of Agronomy, indicate that a ton of lespedeza hay grown on low lime soil fertilized with phosphate and lime produced 164 pounds of lamb gain as compared to 128 pounds' gain from lespedeza hay grown on plots receiving phosphate only. There was also a marked beneficial effect upon wool growth. It would require 4,600 pounds of grain to produce a thousand pounds of lamb gain with free access to the phosphated hay, but only 3,340 pounds of grain if fed hay grown on soil treated with lime and phosphate. An excess of lime or nitrogen or a deficiency of potash also affected gains of rabbits. This emphasizes the importance of a balance of nutrients in the soil if animals are to use feeds efficiently.

Pigs Grow Faster and Require Less Corn. Pigs at the Missouri Station, having an initial weight of 43 pounds, gained nine times as fast when fed corn and a simple mineral mixture on rape and oat pasture than did similar pigs fed corn and minerals in a dry lot. Twenty-five bushels of corn were used for each 100 pounds' gain made by pigs fed in dry lot, as compared to only 6½ bushels by those fed on pasture. Feedstuffs, August 15, 1942.

NEW HAMPSHIRE

Mobilize Forage Resources. In order to obtain more milk and meat, the equivalent of 500 pounds of 0–20–20 should be used on pastures every three years, plus lime when needed. Where pasture area is limited but of excellent quality the use of complete fertilizer is desirable. Where this vegetation is grass and clover, an annual application of 500–600 pounds of 5–10–10 fertilizer may be made. Where grass predominates, use 300 pounds of 10–10–10 or its equivalent. (Editorial note: Substitute grades for 1943 are 4–10–10 and 4–9–7, respectively.) New Hampshire Extension Circular 242.

NEW JERSEY

More Milk Per Acre. In a 1942 survey of good dairy farms by H. R. Cox, extension agronomist, a tendency was found toward carrying more animals per acre, use of complete fertilizer, lime, Ladino clover and alfalfa, with less dependence on blue grass and sweet clover than eight years earlier.

NEW YORK

Fertilized Grass Protects Soil. Fertilized colonial bentgrass and white clover, growing on a 23 per cent slope, gave only .5 per cent run-off in water, and three pounds' soil loss per acre, as compared to an unfertilized colonial bentgrass plot, which gave 8.1 per cent run-off of water, and 267 pounds' soil loss per acre. A bare soil plot, on slightly less slope, gave 48.7 per cent run-off, and soil loss of 17,141 pounds per acre. Another series of permanent pasture plots, of about 11 per cent slope, lightly grazed and fertilized liberally, gave 508 pounds' sheep gain per acre and a soil loss of only 26 pounds per acre. A heavily grazed and similarly fertilized plot gave 618 pounds' sheep gains per acre, but a soil loss of 67 pounds. A third plot, heavily grazed but not fertilized, gave 456 pounds of sheep gain and 163 pounds of soil loss per acre. D. B. Johnston-Wallace, John S. Andrews, and John Lamb, Jr., Jour. Amer. Soc. Agron., Vol. 34, No. 11, 1942.

SOUTH CAROLINA

Lespedeza Increases Production. P. R. Felder, Orangeburg County dairy farmer, stated that milk production in his herd in-

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January Tag Sales

Aggregate fertilizer sales in January in 17 States, as indicated by the sale of tax tags, amounted to 1,090,000 tons. While this was moderately below the sales of 1,167,000 tons in January, 1942, it was abnormally high in comparison with January sales in earlier years.

In 1935–1941, sales in January averaged 435,000 tons, with a peak of 545,000 tons in January, 1941. In those years February sales were about double those in January, and March sales were double those of February. That was the usual seasonal pattern until last year, when the first quarter sales were divided approximately evenly over the three months. As a result of possible shortages and of transportation difficulties, fertilizer was bought earlier than had been the practice in the past. Purchases of tags last month indicate that fertilizer buying is being done early this year also.

Sales in the first seven months of the current fiscal year, from July through January, were 8 per cent larger than in the corresponding period of last year. They were 65 per cent larger than two years ago. These increases reflect in part at least the earlier buying this year. It seems likely, however, that there will be a moderate rise in tonnage in 1943 in view of the crop production program and the sharply rising farm income.

FERTILIZER TAX TAG SALES

State	January 1943 Tons	January 1942 Tons	January 1941 Tons	July–January 1942–43 % '42	July–January 1942–43 Tons	July–January 1941–42 Tons	July–January 1940–41 Tons
Virginia	60,272	93,048	32,650	85	165,773	194,112	134,384
North Carolina	219,452	360,958	107,548	82	431,781	523,850	215,424
South Carolina	154,321	121,173	50,102	138	261,751	189,311	100,908
Georgia	159,843	79,249	45,082	201	288,727	143,479	96,587
Florida	102,274	92,157	81,094	93	384,183	412,562	359,065
Alabama	121,050	105,350	42,900	115	144,500	126,000	60,100
Mississippi	94,164	73,950	63,250	150	191,145	127,825	90,913
Tennessee	13,738	15,539	7,658	126	45,514	36,081	35,126
Arkansas	32,700	37,900	28,550	89	45,308	51,000	36,200
Louisiana	29,400	25,750	38,950	113	68,305	60,400	63,064
Texas	19,225	24,625	20,360	90	45,196	50,230	36,653
Oklahoma	4,100	650	2,500	117	5,541	4,725	4,415
Total South	1,010,539	1,030,349	520,644	108	2,077,724	1,919,575	1,232,839
Indiana	49,850	97,564	7,761	123	248,439	201,829	117,129
Illinois	18,751	15,365	923	122	38,892	31,818	16,473
Kentucky	8,230	16,623	6,088	93	37,931	40,640	32,928
Missouri	3,059	7,579	7,016	65	38,146	58,240	68,414
Kansas	50	15	3,340	38	5,173	13,633	18,558
Total Midwest	79,940	137,146	25,128	106	368,581	346,160	253,502
Grand Total	1,090,479	1,167,495	545,772	108	2,446,305	2,265,735	1,486,341

FERTILIZER MATERIALS MARKET

NEW YORK

Release of Ammonia Liquors Eases Fertilizer Nitrogen Situation. Ammonium Nitrate Also a Possibility. Potash Probably Will Be Ample but Triple Superphosphate Extremely Scarce.

Exclusive Correspondence to "The American Fertilizer"

NEW YORK, February 9, 1943.

Sulphate of Ammonia

The situation in inorganic nitrogen remains easier, due to the additional allocations of various forms of inorganic nitrogen to the fertilizer manufacturers, especially the release of ammonia liquors to them. Further, it is possible that considerable quantities of ammonium nitrate will be available from Canada which fertilizer manufacturers could use if other forms of inorganic nitrogen were not available.

Organic Nitrogen

The situation in organic nitrogen has not changed but it is now expected that the fertilizer manufacturers will be authorized to purchase certain quantities of oil meals for the mixing of fertilizer. Up to this time, however, there has been no indication given as to where fertilizer manufacturers will find the material available for them.

Potash

As previously intimated, there should be sufficient potash in this country for the need of all fertilizer manufacturers. Some importations of Russian potash have been received, but the quantity is a very small percentage of the total American production. It is possible that there was some inequality in the distribution of this material but, as a whole, probably all fertilizer manufacturers will be fairly well taken care of for the season.

Superphosphate

Demand continues and, in certain parts of the country, manufacturers advise that they are over-sold and cannot accept new commitments. Triple superphosphate is still extremely scarce and this situation will continue until deliveries against the Lénd-Lease have been completed.

BALTIMORE

Feed Market Absorbing Practically All Organic Materials. No Surplus of Superphosphate Expected. Paper Bags in Greater Use.

Exclusive Correspondence to "The American Fertilizer"

BALTIMORE, February 9, 1943.

There have been no outstanding features in the fertilizer business during the past two weeks, and ammonia in all forms continues scarce.

Ammoniates.—Tankage and blood are in good demand for feeding purposes at higher ceiling prices than prevail on fertilizer materials, and no stocks are accumulating as feeders are taking materials as fast as produced.

Nitrogenous Material.—There is some action being shown but interest is light and offerings continue scarce.

Vegetable Meals.—There is still a dearth of offerings of vegetable meals for fertilizer purposes, due to the good demand for similar material for feeding purposes.

Sulphate of Ammonia.—Fertilizer manufacturers continue in their efforts to secure increased allocations, but up to the present time have met with little or no success. The consumption of sulphate of ammonia this year will be lower than for many years past.

Nitrate of Soda.—There is no change in the situation. This material is still being allocated by Government agencies, and the greater part of the tonnage tendered is for shipment in bulk, to be used by fertilizer manufacturers in their mixtures to displace sulphate of ammonia.

Superphosphate.—Up to the present time no ceiling prices have been fixed on this commodity although it is rumored that selling prices to dry mixers will be based on cost and freights; as the latter at Southern

ports are lower than Middle Atlantic ports, lower prices are anticipated in the South although the reverse has usually been the case. Manufacturers are now making deliveries against contracts booked last year, and no stocks are accumulating, due the heavy demand for sulphuric acid for which reason manufacturers are only producing for normal requirements.

Bone Meal.—Nothing new to report on either raw or steamed bone meal, both of which are still practically unobtainable except at prohibitive prices.

Bags.—According to Government regulations, new burlap bags are prohibited for use in the shipment of fertilizer although this restriction does not apply to second-hand burlap or to cotton bags. The lower comparative cost of paper bags will probably result in the major portion of fertilizer tonnage this year moving in paper bags.

CHARLESTON

Chilean Nitrate Shipments Increase. Shortage of Practically All Organic Materials. Small Quotas of Nitrogenous Shipped.

Exclusive Correspondence to "The American Fertilizer"

CHARLESTON, February 8, 1943.

Larger quantities of Chilean nitrate of soda are moving into the fertilizer industry at the same prices prevailing in the last few months but the outstanding worry of the fertilizer manufacturers is the shortage of organics.

Nitrogenous.—Some small quotas of one of the nitrogenous tankages, at $3.25 f.o.b. a midwestern point, were allocated during the past week to those buyers who bought it last year, but this does not begin to cover the shortage of organics.

Castor Meal.—The same situation on this prevails that has recently been the case; that is, in spite of larger arrivals of beans, there is still a shortage of the meal.

Dried Blood.—This material is going only to feed. The price for the unground is $5.38 per unit of ammonia ($6.54 per unit N), f.o.b. Chicago.

Cottonseed Meal.—The 8 per cent grade is quoted at $38.60, Atlanta, and soya meal is quoted at $44.75, but these quotations are nominal.

CHICAGO

Allocation of Fertilizer Organics by Distributors Leaves Much Dissatisfaction. Market Conditions Inspire to Poetry.

Exclusive Correspondence to "The American Fertilizer"

CHICAGO, February 8, 1943.

Urgent calls for organics are unabated, but offerings are "few and far between." Sellers have assumed an allocation theory of distribution of their light surplus, which, while finding favor with a few, leaves the majority of manufacturers dissatisfied. The same situation exists in bone meal. An active demand for it from many sections finds no offerings on the market.

In the feed market demand is greater than supply, and no change has occurred in ceiling prices. The present situation reminds one of the old nursery rhyme, which paraphrased could read:

"Fertilizer manufacturers went to the market
To buy some organics and bones.
But when they got there
The market was bare
With many ceilings and zones."

No change in ceiling prices in the various zones. High grade ground fertilizer tankage, $3.85 to $4.00 ($4.68 to $4.98½ per unit N) and 10 cents; standard grades crushed feeding tankage; $5.53 per unit ammonia ($6.72 per unit N); blood, $5.38 ($6.54 per unit N); dry rendered tankage, $1.21 per unit of protein, Chicago basis.

TENNESSEE PHOSPHATE

Early Spring Expected. Shipments of Rock Continue in Volume. Hoover & Mason Install New Equipment. AAA Rock Phosphate Payments Vary.

Exclusive Correspondence to "The American Fertilizer"

COLUMBIA, TENN, February 8, 1943.

The ground hog undoubtedly saw his shadow on February 2nd, but the air was literally filled with wild geese going North last week. Hence both schools of prophecy are at work, with weather right now favoring the belief that spring cannot be far away.

Shipments to all consuming channels are actively under way and stocks in all lines are practically nonexistent.

Hoover & Mason Phosphate Co. have completed installation of a new valve bagging machine with belt conveyors to stock house and direct to box car for loading, complete with automatic weighing and counting devices, having four times the capacity of their old machine. They have purchased two new mills, which will make five.

The AAA benefit payments allowed for use of rock phosphate on permissible crops in the Soil Conservation program are quite variable: Minnesota, $15.00; Illinois, $13.00; Indiana, $11.00; Ohio and Oklahoma, $12.00; a number of other states, $7.50; New York, $6.85; Florida, $4.20; Kansas, about $4.00; and some thirty more states like Mississippi, Alabama, the Virginias, Vermont and New Hampshire make no allowance at all.

The small spreaders used for broadcast distribution of phosphate rock, limestone and occasionally for commercial fertilizer have been deleted from the list of agricultural implements frozen last November and can now be purchased, when obtainable, without rationing permits.

PHILADELPHIA

Chemical Nitrogen Situation Improves. More Nitrate of Soda Available. Fish Scrap Out of Fertilizer Market for Spring Season

Exclusive Correspondence to "The American Fertilizer"

PHILADELPHIA, February 8, 1943.

Probably the main feature of the past couple of weeks has been the easing of the tight position of chemical nitrogen products, and further advices of additional quantities of Russian muriate of potash being shipped to this country. Otherwise, market remains about the same as previously reported.

Ammoniates.—All ammoniates remain scarce. Recently some low-grade ammoniates have appeared on the market, but have been booked up rapidly; fertilizer mixers are now finding only distant future shipments available.

Nitrogenous Tankage.—All suppliers are apparently booked far ahead, and are allocating available supply.

Sulphate of Ammonia.—This material is being allocated, but a little more liberally.

Nitrate of Soda.—Reports are that sizable quantities of Chilean material are moving into the fertilizer industry, but it is still being allocated.

Fish Scrap.—Catches have been extremely poor, with the result that fertilizer mixers will probably have to forget about this item for the spring season.

Potash.—Mixers who had failed to cover on contracts, are being helped somewhat by the arrival of Russian muriate.

War Crop Advances to Encourage Production

On February 5th, Secretary of Agriculture Wickard announced a program of special aid to farmers to encourage additional production of specified war crops and to insure producers against loss in the case of high risk crops or crops which they would not otherwise undertake to grow.

The aid will be in the form of "special war crop advances," to be extended through the U. S. Department of Agriculture County War Boards and the Regional Agricultural Credit Corporation of the Farm Credit Administration.

Farmers making extra efforts to grow the vital war crops and assuming the added risks of production in cases of crops which they ordinarily would not grow, will sign a special form of note limiting the obligation to repay to the value of the crops produced, provided certain requirements are met. These include a finding by the County War Board that the farmer has used the money in the production of crops for which it was advanced; that he diligently applied the principles of good farming to the production of the crops; that he has harvested the crops to the extent of his ability; and that he has applied the full proceeds of such crops to the repayment of the advance.

The following crops were specified for the special advances: soybeans for beans, flax for seed or fiber, peanuts to be harvested and picked, potatoes where the farm goal is three acres or more, sweet potatoes on farms with goals determined, American-Egyptian cotton, hemp for seed or fiber, dry beans, dry peas (excluding wrinkled varieties), castor beans, tomatoes, snap beans, lima beans, peas, carrots, for processing or sale fresh; and cabbage, sweet corn, and table beets, for processing only.

In making loans to help farmers finance production activities other than the special war crop advances, the U. S. D. A. County War Boards and the Regional Agricultural Credit Corporation will require full personal liability and a first lien on the crops, livestock, or equipment financed, and farmers will be responsible for the full amount of the loans, in any event.

Loans will be repaid when crops or livestock financed are sold, and such loans ordinarily will not exceed one year. Unpaid balances of loans for livestock, machinery, etc., may be renewed or extended but at least one-third of the amount advanced for necessary war production capital purposes should be repaid the first year.

Secretary Wickard also announced that in most parts of the country the State War Boards have appointed loan representatives to work with the U. S. D. A. County War Boards and loans or advances are available to those who can qualify.

"The purpose of these loans," he said, "is to help farmers meet or surpass the exceedingly high 1943 production goals which they have set, where that help is necessary, by making credit available to enable every producer to produce essential products to the limit without being hampered by inadequate finances.

"On the other hand," he added, "such credit is not a substitute for other sources, nor is it intended to compete with other lenders. Other lenders are urged to meet the credit needs of farmers, but the resources of the government are available to see to it that production is not curtailed for lack of credit."

Superphosphate Production, 1942

December statistics on superphosphate, announced by Director J. C. Capt, Bureau of the Census, Department of Commerce, show that production amounted to 485,276 tons, an increase of 3.8 per cent over the 467,520 tons reported for November, 1942, and an increase of 12 per cent over the 433,385 tons reported for December a year ago. Shipments in December, 1942, amounted to 351,596 tons, a decrease of 0.8 per cent from the 354,473 tons reported for November, 1942, but an increase of 24.8 per cent over the 281,616 tons reported for December, 1941. Stocks on hand at the end of December, 1942, amounted to 973,224 tons, a decrease of 2.3 per cent from the 996,130 tons reported for the previous month, but an increase of 4.3 per cent over 932,683 tons reported for December, 1941. Comparability of the data on receipts, shipments, and stocks is slightly affected by the reclassification of certain quantities of superphosphate formerly reported in dry base and mixed goods. The item dry base and mixed goods was dropped from the published report in August. Since then, the superphosphate formerly included in dry base and mixed goods has been reported as either normal or concentrated superphosphate. Data for this report were obtained from reports by 52 manufacturers, representing 95 per cent of the total value of superphosphate as reported at the Biennial Census of Manufactures, 1939.

Beginning with the month of September, 1942, statistics relating to production, receipts, shipments, and stocks include all grades of superphosphate (normal, concentrated, and wet base goods) converted to a basis of 18 per cent available phosphoric acid. The reports for months prior to September, 1942, showed data on a 16 per cent basis. However, for comparative purposes they have been converted to 18 per cent A. P. A. basis in the table.

Item	1942		1941	1940	Total, year (January–December)		
	December	November	December	December	1942	1941	1940
Stocks on hand beginning of month	996,130	1,029,415	[1]933,896	[2]1,106,896	....	....	....
Production	485,276	467,520	433,385	377,883	5,144,484	4,326,402	3,898,641
Received from other acidulators (including exchange transfers)[3]	7,128	10,891	52,275	44,315	289,929	509,693	411,618
Book adjustments (account of inventories)	48,105	+1,677	+85	−911	−15,599	−4,230	−28,792
Total Supply	1,496,639	1,509,503	1,419,641	1,527,647	....	....	....
Disposition, total	523,415	513,373	[4]	[4]	[4]	[4]	[4]
Shipments, total	351,596	354,473	281,616	198,065	3,961,362	3,633,871	2,934,336
To mixers	188,244	169,055	140,152	123,156	1,916,772	1,638,026	1,530,474
To other acidulators (including exchange transfers)	50,790	42,486	70,252	36,516	541,225	659,514	471,855
To all others (including Government agencies)	112,562	142,932	71,212	38,393	1,503,365	1,336,331	932,007
Used in reporting plants	171,819	158,900	[4]	[4]	[4]	[4]	[4]
Stocks on hand, end of month	973,224	996,130	932,683	1,142,585	....	....	....

[1] Reported as stocks on hand November 30, 1941.
[2] Reported as stocks on hand November 30, 1940.
[3] Data for September to December, 1942, exclude base and mixed goods; data for other months shown include base and mixed goods.
[4] Not available.

Use of Cottonseed Meal or Cake for Fertilizer Covered in Order

Conditions under which cottonseed meal or cake may be used in the manufacture of mixed fertilizer for sale were announced on February 10th by the U. S. Department of Agriculture. The purpose is to make existing supplies of cake and meal available for livestock feeding, as well as to make possible the use of these oilseed products in the production of necessary war crops.

On December 31, 1942, the Commodity Credit Corporation issued Oilseed Order No. 7 prohibiting after January 2nd, and until further notice, the purchase or acceptance of delivery of oilseed meal for use in the manufacture of mixed fertilizer for sale. These restrictions are continued in Food Production Order No. 8, but with two exceptions as applied to cottonseed meal and cake.

The new order provides that the prohibition shall not apply to cottonseed oil meal or cake required from a farmer who had acquired the meal or cake prior to January 2, 1943, and of which the organic nitrogen content—together with the total quantity of organic nitrogen otherwise acquired for use in the manufacture of mixed fertilizer for sale during the period July 1, 1942 to June 30, 1943—does not exceed 80 per cent of the quantity of organic nitrogen used during the period July 1, 1941 to June 30, 1942.

Exception is made also in cases where cottonseed oil meal or cake is to be used—with the approval of the Director of Food Production—in the manufacture and sale of mixed fertilizer for use on citrus fruits, cigar leaf tobacco, and vegetables listed among the "A" crops under Food Production Order No. 5—chemical fertilizer. The vegetables on this list include dry beans, snap and lima beans, beets, cabbage, carrots, kale, onions, all peas, peppers, Irish and sweet potatoes, spinach, sweet corn, tomatoes, and vegetable seeds.

Officials explained that in the eastern Cotton Belt it is common practice for farmers to exchange their cottonseed for cottonseed meal in the autumn, and then in the following spring to exchange cottonseed meal for fertilizer. Large quantities of 1942 crop cottonseed were exchanged for meal, but to date little meal has been exchanged for fertilizer. It is now possible for fertilizer manufacturers to exchange fertilizer for cottonseed meal, and then, within the limits established by the order, to use the meal in the manufacture of additional quantities of fertilizer, and to sell the excess for the feeding of livestock. Under the order, the fertilizer manufacturer is required to offer for sale the oil meal obtained in exchange whenever he has used in the manufacture of fertilizer 80 per cent of the organic nitrogen that he used last year.

Officials expect that the new provisions will tend to free supplies of cottonseed meal for immediate use as feed and fertilizer. This will increase the available supply of high-protein feed for the production of meats, milk, and eggs, and help relieve a critical shortage of organic fertilizer materials needed in the production of war crops.

The order provides that fertilizer manufacturers may obtain an allocation of cottonseed meal from the Director of Food Production and then purchase such meal from available sources for the purpose of selling it for use on citrus fruits, cigar leaf tobacco and the list "A" vegetable crops. The quantity of meal to be approved for fertilizer manufacturers for use on these crops will be established by the Food Production Administration on the basis of information obtained directly from fertilizer manufacturers.

Allocations will be made after taking into consideration (1) the units of organic nitrogen in materials used in mixed fertilizer for

the 1941–42 season; (2) the quantity of organic nitrogen which has been available for such fertilizers for the present season up to January 11; (3) the quantity of organic nitrogen the fertilizer mixer has on hand or under contract to be used in mixed fertilizer up to June 30, 1943; (4) the estimated minimum requirements of cottonseed meal needed, by months, in the production of citrus fruits, cigar leaf tobacco, and "A" vegetable crops.

It is provided also that, notwithstanding existing contracts or commitments, in any case where oilseed meals cannot be delivered to fertilizer manufacturers because of the prohibitions of F. P. Order No. 8, such meal may promptly be offered for sale for feeding purposes.

No Restriction on Chemical Nitrogen Content of Victory Garden Fertilizer

The Department of Agriculture's chemical fertilizer order, Food Production Order No. 5, which went into effect January 18, 1943, places no restriction on the chemical nitrogen content of grade 3–8–7, the victory garden fertilizer, it was explained recently by M. Clifford Townsend, Director of Food Production.

The 3 per cent nitrogen content of this grade may consist entirely of chemical nitrogen or of organic nitrogen, or it may consist of both in any ratio desired by the manufacturer of victory garden fertilizer, Mr. Townsend said.

Under the War Production Board Order No. M-231, which is now superseded by "Food Production Order No. 5—Chemical Fertilizer," the nitrogen content of grade 3–8–7 had to consist of one-half per cent chemical nitrogen and 2½ per cent organic nitrogen.

Bill to Require Observance of State Fertilizer Laws

Senator Andrews and Representative Peterson, of Florida, have introduced into the U. S. Senate and the House, respectively, bills to require U. S. D. A. or any other agency of the U. S. Government, when distributing seeds or fertilizer or soil-conditioning or fertilizer material to farmers, to comply with the respective laws of the State within which such material is distributed. A similar bill was introduced into the House in December by Representative Peterson, but was not enacted before adjournment of the 77th Congress. It will be recalled that last fall a three-judge Federal Court at Tallahassee enjoined State officials of Florida from collecting, with respect to AAA fertilizer, the inspection fee of 25 cents fixed by the law of that State.

Floyd to Head North Carolina-Virginia Institute

E. Y. Floyd has resigned his position as Federal executive assistant, AAA, to become director of the North Carolina-Virginia Plant Food Institute, succeeding E. P. Gulledge.

Mr. Floyd graduated from North Carolina State College in 1920 and returned to the college in December, 1925, to develop tobacco extension work. In 1933 he was assigned to handle flue-cured and burley tobacco, peanuts, and potatoes under the AAA program, later serving as State executive officer until July 1, 1942, when he was named Federal executive assistant. Mr. Floyd is one of the best-known agricultural leaders in North Carolina and highly regarded by all who know him.

$194,000,000 Saving to Farmers

"Fertilizer went up 86 per cent in price during the last war. This time, it has been held to 13 per cent with a saving to farmers this year (1942) alone of $194,000,000."—LEON HENDERSON, *ex-Price Administrator*.

In contrast to the low level of fertilizer prices, the prices received by farmers for their products have gone up about as much in this war as in the corresponding period of the last war. In 1917, farm product prices were 173 per cent of 1914, the first war year. In 1942, farm product prices were 171 per cent of 1939.

The price situation pointed out by Mr. Henderson cannot be attributed to the effect of price controls, since fertilizer prices have been low in comparison with other commodities for many years. In 1940, when farm product prices advanced 7 per cent and the demand for fertilizer was increasing, there was a 3 per cent decline in fertilizer prices. In 1915 there was a 12 per cent rise. The highly competitive commercial fertilizer industry, under private ownership and management, has kept prices at a level favorable to farmers.

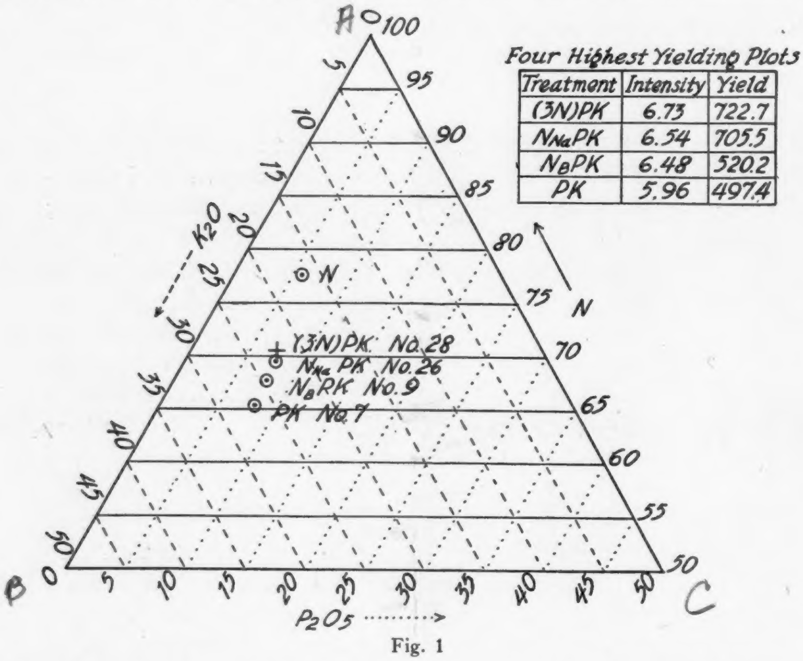
LEAF ANALYSIS AS A MEANS OF DETERMINING THE FERTILIZER REQUIREMENTS OF CROPS

(Continued from page 7)

larger scale only the upper half of the triangle is drawn. Starting from the base line BC, lines are drawn at equal intervals parallel to it. Similarly, lines are drawn parallel to the sides AC and AB respectively. The apex or summit A represents 100 units of nitrogen, the left base apex B, 100 units of potash, and the right base apex C, 100 units of phosphoric acid. As a point moves up towards the summit A, therefore, the proportion of nitrogen in the *NPK-unit* progressively increases until at A it becomes 100 per cent. Similarly, as a point moves from the side AC towards the apex B the proportion of potash increases until at the apex the unit is composed 100 per cent of potash. As a point moves away from the side AB the phosphoric acid in the unit progressively increases and likewise becomes 100 per cent at the apex opposite this side. The direction of increasing values for nitrogen, phosphoric acid and potash are indicated by arrows in the figure.

The locus of the *NPK-unit* of the highest yielding of the plots we are considering, namely (3N)PK, No. 28, is marked by a cross and the loci of the other treatments are indicated by dots. It is to be noted that the locus of NPK, No. 26, the second highest yielding plot is quite near that of the optimum No. 28, and is nearer than any of the others. Moreover, it is also to be observed that the much greater difference in yields between Nos. 28 and 26 on the one hand and Nos. 9 and 7 on the other is reflected in the figure by the loci of the latter being much further removed from that of the optimum than is No. 26.

We could amplify this illustration by many more examples from our experiments. Thus, in the figure the locus of the *NPK-unit* for the plot No. 2 which received the unit amount of



Treatment	Intensity	Yield
(3N)PK	6.73	722.7
N_{Na}PK	6.54	705.5
N_BPK	6.48	520.2
PK	5.96	497.4

Fig. 1

nitrogen in the form of dried blood without phosphoric acid on potash is shown also.

The yield of this plot is very low (266 lb.). Associated with this low yield is a low intensity (4.67) and a position of the locus of the *NPK-unit* far removed from the optimum, resulting from too high a value for nitrogen in relation to phosphoric acid and potash.

The leaf analysis of this plot, No. 2, receiving only nitrogen, may be used also to prevent the reader from concluding from an inspection of column 2, Table I, that analysis of the leaf for nitrogen alone would be sufficient. Table II gives the data for this plot.

The percentage of nitrogen in the leaf is 2.540, a value which is interbetween NPK, No. 9, and PK, No. 7. But the yield of the

N plot, No. 2, is only 266 lb. compared with 497 lb. from PK, No. 7. The percentage content of nitrogen in plot No. 2, therefore, does not supply the answer to the low yield. An explanation, however, is furnished by the *NPK-unit* values, for we see that the locus of the unit of this N plot, No. 2, is far removed from the locus of the optimum; nitrogen is too high relative to phosphoric acid and potash.

TABLE II

Plot	N %	P_2O_5 %	K_2O %	Intensity ($N+P_2O_5+K_2O$)
No. 2	2.540	0.312	1.821	4.673

Composition of the NPK-unit $N : P_2O_5 : K_2O$	Yield of grain (lbs.)
77.61 : 5.78 : 16.61	266

The experimental facts show that any treatment that will cause the locus of a point to approach or coincide with that of the optimum will cause the yields to approach or to be equal to that of the optimum.

Of course, this optimum is not a fixed constant because the NPK nutrition resulting from a particular fertilizer applied to a given species is not a definite absolute every year, for the NPK nutrition depends on other factors also which vary with the year or season. By carrying out the experiments over a sufficient number of years, the limits of the changes in the NPK nutrition of a given species can be determined. However, for any given species, in a particular soil, in a particular year, the method of leaf analysis outlined supplies information of a precise nature by indicating the nature of the lack of balance between the fertilizer elements.

The longer the period of observation, that is, the greater the number of times samples are taken during the growing season, the more complete is the picture. In the examples we have chosen the analysis represents the mean of samples taken on July 6, July 21, August 8, and August 25, and consequently it represents the resultant of all the factors operating during the growth season. Much information is given, however, at the earliest sampling.

The procedure of diagnosis by means of the relatively simple method of collecting a few leaves places in the hands of the investigator a valuable tool that enables him through a knowledge of the nutrition of his plants to secure more information than can be obtained in any other way.

PASTURE NOTES

(Continued from page 11)

creased from 38 cans per week to 47 after he turned his milking herd on treated lespedeza pastures.

TEXAS

Extend Grazing with Fertilizer. Use of superphosphate, potash and lime on soil deficient in those elements, maintains clover and makes earlier grazing in the spring, extends the lespedeza grazing by several weeks in summer, and causes Bermuda grass to start earlier in the spring and remain green later in the fall. Well-nourished pastures in fertile soil endure drought, heat, and cold better, and respond quicker and more effectively to moisture than on poor land. It is not uncommon to double and treble productivity by fertilizing pastures, according to R. R. Lancaster, pasture specialist, Texas A. & M. College.

Phosphorus Increases Beef. Supplying phosphorus to cows on phosphorus-deficient range increased the calf crop about 30 per cent and weaning weights, on the average, about 70 pounds per calf due to increased milk flow. W. H. Black, N. R. Ellis, and J. M. Jones, Amer. Soc. An. Prod., Dec. 1–2, 1942.

VIRGINIA

Available Phosphorus Important. In a seven-year study of the relative efficiencies of different phosphorus carriers on pasture yield and composition, results were in the following descending order: dicalcium, normal, triple phosphate, basic slag, tricalcium, and raw rock phosphate. Dicalcium phosphate gave an increase over the limed check plots of 1,548 pounds per acre or 56 per cent in herbage yield. On unlimed plots normal superphosphate was fully as effective as dicalcium phosphate. Liming alone caused a slight reduction in yield with every phosphate carrier used and also with no phosphate. The average annual uptake of phosphoric acid was approximately equal to the amount that was applied in readily available phosphate fertilizer, while on the check plots the uptake was only about 20 pounds per acre.

WISCONSIN

Graze Alfalfa to Save Labor. Pasturing alfalfa heavily for five to seven days after it reaches a height of about three inches may reduce yield up to 25 per cent but will improve the quality of hay and spread hay harvesting time. It is not recommended for new seedings on poor sandy soil or where winter injury has been severe.

See Page 4

BUYERS' GUIDE • A CLASSIFIED INDEX TO ALL THE ADVERTISERS IN "THE AMERICAN FERTILIZER"

This list contains representative concerns in the Commercial Fertilizer Industry, Including fertilizer manufacturers, machinery and equipment manufacturers, dealers in and manufacturers of commercial fertilizer materials and supplies, brokers, chemists, etc.
For Alphabetical List of Advertisers, see page 37.

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Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.

ACID EGGS
Chemical Construction Corp., New York City.

ACIDULATING UNITS
Chemical Construction Corp., New York City.
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St. Regis Paper Co., New York City.
Textile Bag Mfrs. Association, Chicago, Ill.
Union Bag & Paper Corporation, New York City.

BAGS—Cotton
Bemis Bro. Bag Co., St. Louis, Mo.
Textile Bag Mfrs. Association, Chicago, Ill.

BAGS—Paper
Bagpak, Inc., New York City
Bemis Bro. Bag Co., St. Louis, Mo.
St. Regis Paper Co., New York City.
Union Bag & Paper Corporation, New York City.

BAGS (Waterproof)—Manufacturers
Bemis Bro. Bag Co., St. Louis, Mo.
St. Regis Paper Co., New York City.
Textile Bag Mfrs. Association, Chicago, Ill,
Union Bag & Paper Corporation, New York City.

BAGS—Dealers and Brokers
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
McIver & Son, Alex. M., Charleston, S. C.
Wellmann, William E., Baltimore, Md.

BAG CLOSING MACHINES
Bagpak Inc., New York City.

BAGGING MACHINES—For Filling Sacks
Atlanta Utility Works, East Point, Ga.
Bagpak, Inc., New York City.
Sackett & Sons Co., The A. J., Baltimore, Md.

BAG PILERS
Link-Belt Company, Philadelphia, Chicago.

BEARINGS
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

BELT LACING
Sackett & Sons Co., The A. J., Baltimore, Md.

BELTING—Chain
Atlanta Utility Works, East Point, Ga.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

BELTING—Leather, Rubber, Canvas
Sackett & Sons Co., The A. J., Baltimore, Md.

BOILERS—Steam
Atlanta Utility Works, East Point, Ga.

BONE BLACK
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Huber & Company, New York City.

BONE PRODUCTS
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
McIver & Son, Alex. M., Charleston, S. C.
Schmaltz, Jos. H., Chicago, Ill.
Wellmann, William E., Baltimore, Md.

BORAX AND BORIC ACID
American Potash and Chem. Corp., New York City.
Pacific Coast Borax Co., New York City.

BROKERS
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Dickerson Co., The, Philadelphia, Pa.
Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
Keim, Samuel L., Philadelphia, Pa.
McIver & Son, Alex. M., Charleston, S. C.
Schmaltz, Jos. H., Chicago, Ill.
Wellmann, William E., Baltimore, Md.

BUCKETS—Elevator
Link-Belt Company, Philadelphia, Chicago
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

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BUCKETS—For Hoists, Cranes, etc., Clam Shell, Orange Peel, Drag Line, Special; Electrically Operated and Multi Power
Hayward Company, The, New York City.
Link-Belt Company, Philadelphia, Chicago.

BURNERS—Sulphur
Chemical Construction Corp., New York City.

BURNERS—Oil
Monarch Mfg. Works, Inc., Philadelphia, Pa.
Sackett & Sons Co., The A. J., Baltimore, Md.

CABLEWAYS
Hayward Company, The, New York City.

CARBONATE OF AMMONIA
American Agricultural Chemical Co., New York City.
DuPont de Nemours & Co., E. I., Wilmington, Del.

CARS—For Moving Materials
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CARTS—Fertilizer, Standard and Roller Bearing
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.

CASTINGS—Acid Resisting
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Duriron Co., Inc., The, Dayton, Ohio.

CASTINGS—Iron and Steel
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CEMENT—Acid-Proof
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.

CHAIN DRIVES—Silent
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CHAINS AND SPROCKETS
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CHAMBERS—Acid
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.

CHEMICAL APPARATUS
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Duriron Co., Inc., The, Dayton, Ohio.
Monarch Mfg. Works, Inc., Philadelphia, Pa.

CHEMICALS
American Agricultural Chemical Co., New York City.
American Cyanamid Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Barrett Division, The, Allied Chemical & Dye Corp., New York City.
Bradley & Baker, New York City.
DuPont de Nemours & Co., E. I., Wilmington, Del.
Huber & Company, New York City.

CHEMICALS—Continued
International Minerals & Chemical Corporation, Chicago, Ill
McIver & Son, Alex. M., Charleston, S. C.
Phosphate Mining Co., The, New York City.
Wellmann, William E., Baltimore, Md.

CHEMICAL PLANT CONSTRUCTION
Atlanta Utility Works, East Point, Ga.
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CHEMISTS AND ASSAYERS
Gascoyne & Co., Baltimore, Md.
Shuey & Company, Inc., Savannah, Ga.
Stillwell & Gladding, New York City.
Wiley & Company, Baltimore, Md.

CLUTCHES
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CONCENTRATORS—Sulphuric Acid
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.

CONDITIONERS AND FILLERS
American Limestone Co., Knoxville, Tenn.
Dickerson Co., The, Philadelphia, Pa.
Phosphate Mining Co., The, New York City.

CONTACT ACID PLANTS
Chemical Construction Corp., New York City.

COPPER SULPHATE
Tennessee Corporation, Atlanta, Ga.

COTTONSEED PRODUCTS
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City
Jett, Joseph C., Norfolk, Va.
McIver & Son, Alex. M., Charleston, S. C.
Schmaltz, Jos. H., Chicago, Ill.
Wellmann, William E., Baltimore, Md.

CRANES AND DERRICKS
Hayward Company, The, New York City.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

CYANAMID
American Agricultural Chemical Co., New York City
American Cyanamid Co., New York City.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Jett, Joseph C., Norfolk, Va.
Wellmann, William E., Baltimore, Md.

DENS—Superphosphate
Chemical Construction Corp., New York City.
Stedman's Foundry and Mach. Works, Aurora, Ind.

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Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

DRYERS—Direct Heat
Sackett & Sons Co., The A. J., Baltimore, Md.

DRIVES—Electric
Link-Belt Company, Philadelphia, Chicago.

DUMP CARS
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

DUST COLLECTING SYSTEMS
Sackett & Sons Co., The A. J., Baltimore, Md.

ELECTRIC MOTORS AND APPLIANCES
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.

ELEVATORS
Atlanta Utility Works, East Point, Ga.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

ELEVATORS AND CONVEYORS—Portable
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

ENGINEERS—Chemical and Industrial
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

ENGINES—Steam
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.

EXCAVATORS AND DREDGES—Drag Line and Cableway
Hayward Company, The, New York City.
Link-Belt Company, Philadelphia, Chicago.
Link Belt Speeder Corp., Chicago, Ill., and Cedar Rapids, Iowa.

FERTILIZER MANUFACTURERS
American Agricultural Chemical Co., New York City.
American Cyanamid Company, New York City.
Armour Fertiliser Works, Atlanta, Ga.
Farmers Fertilizer Company, Columbus, Ohio.
International Minerals and Chemical Corporation, Chicago, Ill.
Phosphate Mining Co., The, New York City.
U. S. Phosphoric Products Division, Tennessee Corp., Tampa, Fla.

FISH SCRAP AND OIL
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
McIver & Son, Alex. M., Charleston, S. C.
Wellmann, William E., Baltimore, Md.

FOUNDERS AND MACHINISTS
Atlanta Utility Works, East Point, Ga.
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

GARBAGE TANKAGE
Wellmann, William E., Baltimore, Md.

GEARS—Machine Moulded and Cut
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

GEARS—Silent
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

GELATINE AND GLUE
American Agricultural Chemical Co., New York City.

GUANO
Baker & Bro., H. J., New York City.

HOISTS—Electric, Floor and Cage Operated, Portable
Hayward Company, The, New York City.

HOPPERS
Atlanta Utility Works, East Point, Ga.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

IMPORTERS, EXPORTERS
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Wellmann, William E., Baltimore, Md.

IRON SULPHATE
Tennessee Corporation, Atlanta, Ga.

INSECTICIDES
American Agricultural Chemical Co., New York City.

LACING—Belt
Sackett & Sons Co., The A. J., Baltimore, Md.

LIMESTONE
American Agricultural Chemical Co., New York City.
American Limestone Co., Knoxville, Tenn.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
McIver & Son, Alex. M., Charleston, S. C.
Wellmann, William E., Baltimore, Md.

LOADERS—Car and Wagon, for Fertilizers
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

MACHINERY—Acid Making
Atlanta Utility Works, East Point, Ga.
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.
Duriron Co., Inc., The, Dayton, Ohio.
Fairlie, Andrew M., Atlanta, Ga.
Monarch Mfg. Works, Inc., Philadelphia, Pa.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MACHINERY—Coal and Ash Handling
Hayward Company, The, New York City.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

MACHINERY—Elevating and Conveying
Atlanta Utility Works, East Point, Ga.
Hayward Company, The, New York City.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MACHINERY—Grinding and Pulverizing
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

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MACHINERY—Power Transmission
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MACHINERY—Pumping
Atlanta Utility Works, East Point, Ga.
Duriron Co., Inc., The, Dayton, Ohio.

MACHINERY—Tankage and Fish Scrap
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MAGNETS
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MANGANESE SULPHATE
McIver & Son, Alex. M., Charleston, S. C.
Tennessee Corporation, Atlanta, Ga.

MIXERS
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

NITRATE OF SODA
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Barrett Division, The, Allied Chemical & Dye Corp., New York City.
Bradley & Baker, New York City.
Chilean Nitrate Sales Corp., New York City.
Huber & Company, New York City.
International Minerals & Chemical Corporation, Chicago, Ill.
McIver & Son, Alex. M., Charleston, S. C.
Schmaltz, Jos. H., Chicago, Ill.
Wellmann, William E., Baltimore, Md.

NITRATE OVENS AND APPARATUS
Chemical Construction Corp., New York City.

NITROGEN SOLUTIONS
Barrett Division, The, Allied Chemical & Dye Corp., New York City.

NITROGENOUS ORGANIC MATERIAL
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
DuPont de Nemours & Co., Wilmington, Del.
Huber & Company, New York City.
International Minerals & Chemical Corporation, Chicago, Ill.
McIver & Son, Alex. M., Charleston, S. C.
Smith-Rowland Co., Norfolk, Va.
Wellmann, William E., Baltimore, Md.

NOZZLES—Spray
Monarch Mfg. Works, Philadelphia, Pa.

PACKING—For Acid Towers
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.

PANS AND POTS
Stedman's Foundry and Mach. Works, Aurora, Ind.

PHOSPHATE MINING PLANTS
Chemical Construction Corp., New York City.

PHOSPHATE ROCK
American Agricultural Chemical Co., New York City.
American Cyanamid Co., New York City
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
International Minerals & Chemical Corporation, Chicago, Ill.
Jett, Joseph C., Norfolk, Va.
McIver & Son, Alex. M., Charleston, S. C.
Phosphate Mining Co., The, New York City.
Ruhm, H. D., Mount Pleasant, Tenn.
Schmaltz, Jos. H., Chicago, Ill.
Southern Phosphate Corp., Baltimore, Md.
Virginia-Carolina Chemical Corp. (Mining Dept.), Richmond, Va.
Wellmann, William E., Baltimore, Md.

PIPE—Acid Resisting
Duriron Co., Inc., The, Dayton, Ohio.

PIPES—Chemical Stoneware
Chemical Construction Corp., New York City.

PIPES—Wooden
Stedman's Foundry and Mach. Works, Aurora, Ind.

PLANT CONSTRUCTION—Fertilizer and Acid
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.

POTASH SALTS—Dealers and Brokers
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
International Minerals & Chemical Corporation, Chicago, Ill.
Jett, Joseph C., Norfolk, Va.
Schmaltz, Jos. H., Chicago, Ill.
Wellmann, William E., Baltimore, Md.

POTASH SALTS—Manufacturers
American Potash and Chem. Corp., New York City.
Potash Co. of America, New York City.
International Minerals & Chemical Corp., Chicago, Ill.
United States Potash Co., New York City.

PULLEYS AND HANGERS
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

PUMPS—Acid-Resisting
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Duriron Co., Inc., The, Dayton, Ohio.
Monarch Mfg. Works, Inc., Philadelphia, Pa.

PYRITES—Brokers
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., New York City.
Wellmann, William E., Baltimore, Md.

QUARTZ
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.

RINGS—Sulphuric Acid Tower
Chemical Construction Corp., New York City.

ROUGH AMMONIATES
Bradley & Baker, New York City.
McIver & Son, Alex. M., Charleston, S. C.
Schmaltz, Jos. H., Chicago, Ill.
Wellmann, William E., Baltimore, Md.

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Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

SCRAPERS—Drag
Hayward Company, The, New York City.

SCREENS
Atlanta Utility Works, East Point, Ga.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

SEPARATORS—Air
Sackett & Sons Co., The A. J., Baltimore, Md.

SEPARATORS—Including Vibrating
Sackett & Sons Co., The A. J., Baltimore, Md.

SEPARATORS—Magnetic
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

SHAFTING
Atlanta Utility Works, East Point, Ga.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

SHOVELS—Power
Link-Belt Company, Philadelphia, Chicago.
Link-Belt Speeder Corporation, Chicago, Ill., and Cedar Rapids, Iowa.
Sackett & Sons Co., The A. J., Baltimore, Md.

SPRAYS—Acid Chambers
Monarch Mfg. Works, Inc., Philadelphia, Pa.

SPROCKET WHEELS (See Chains and Sprockets)

STACKS
Sackett & Sons Co., The A. J., Baltimore, Md.

SULPHATE OF AMMONIA
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Barrett Division, The, Allied Chemical & Dye Corp., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
Hydrocarbon Products Co., New York City.
Jett, Joseph C., Norfolk, Va.
McIver & Son, Alex. M., Charleston, S. C.
Schmaltz, Jos. H., Chicago, Ill.
Wellmann, William E., Baltimore, Md.

SULPHUR
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Freeport Sulphur Co., New York City.
Texas Gulf Sulphur Co., New York City.

SULPHURIC ACID
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
International Minerals & Chemical Corporation, Chicago, Ill.
Jett, Joseph C., Norfolk, Va.
McIver & Son, Alex. M. Charleston, S. C.

SULPHURIC ACID—Continued
U. S. Phosphoric Products Division, Tennessee Corp., Tampa, Fla.
Wellmann, William E., Baltimore, Md.

SUPERPHOSPHATE
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
International Minerals & Chemical Corporation, Chicago, Ill.
Jett, Joseph C., Norfolk, Va.
McIver & Son, Alex. M., Charleston, S. C.
Schmaltz, Jos. H., Chicago, Ill.
U. S. Phosphoric Products Division, Tennessee Corp., Tampa, Fla.
Wellmann, William E., Baltimore, Md.

SUPERPHOSPHATE—Concentrated
Armour Fertilizer Works, Atlanta, Ga.
International Minerals & Chemical Corporation, Chicago, Ill.
Phosphate Mining Co., The, New York City.
U. S. Phosphoric Products Division, Tennessee Corp., Tampa, Fla.

SYPHONS—For Acid
Monarch Mfg. Works, Inc., Philadelphia, Pa.

TALLOW AND GREASE
American Agricultural Chemical Co., New York City.

TANKAGE
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
International Minerals & Chemical Corporation, Chicago, Ill.
Jett, Joseph C., Norfolk, Va.
McIver & Son, Alex. M., Charleston, S. C.
Schmaltz, Jos. H., Chicago, Ill.
Smith-Rowland, Norfolk, Va.
Wellmann, William E., Baltimore, Md.

TANKAGE—Garbage
Huber & Company, New York City.

TANKS
Sackett & Sons, Co., The A. J., Baltimore, Md.

TILE—Acid-Proof
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.

TOWERS—Acid and Absorption
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.

UNLOADERS—Car and Boat
Hayward Company, The, New York City.
Sackett & Sons Co., The A. J., Baltimore, Md.

UREA
DuPont de Nemours & Co., E. I., Wilmington, Del.

UREA-AMMONIA LIQUOR
DuPont de Nemours & Co., E. I., Wilmington, Del.

VALVES—Acid-Resisting
Atlanta Utility Works, East Point, Ga.
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Duriron Co., Inc., The, Dayton, Ohio.
Monarch Mfg. Works, Inc., Philadelphia, Pa.

WHEELBARROW (See Carts)

ZINC SULPHATE
Tennessee Corporation, Atlanta, Ga.

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